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Sell or not sell biodiesel: Local competition and government measures☆

Jordi Perdiguero[a,*], Juan Luis Jiménez[b,1]

[a] Departamento de Política Económica, Grup de Recerca en Governs i Mercats (GiM), Institut de Recerca en Economia Aplicada (IREA), Avda. Diagonal 690, 08034 Barcelona, Spain
[b] Grupo de Economía de las Infraestructuras y el Transporte (EIT), Universidad de Las Palmas de Gran Canaria, Facultad de Economía, Empresa y Turismo, Despacho D, 2-12, Campus de Tafira, 35017 Las Palmas, Spain

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ABSTRACT

The introduction of biofuels is one of the objectives of the European Union. For this reason, measures to promote the production and consumption of this product have been implemented, such as tax exemptions, fixing a minimum amount of mixture or the introduction of public transport that consume biofuels. In this paper, we test different factors that can affect the introduction of biodiesel in the Spanish gasoline market. These factors are mainly the level of local competition, technical difficulties and local government action. Empirical evidence shows that a higher level of competition, more buses that consume biodiesel and a lower adjustment costs increase significantly the probability of sell biodiesel at service stations. These results show how the promotion of competition and public procurement of vehicles can improve the commercialization of biofuels.

Contents

1. Introduction

The introduction of biofuels to the automotive market is a clear objective within the European Community (EC). In fact, EC has established a policy that sets minimum levels of biofuels sold in each member state. The objective of the European Community to replace fossil fuels with biofuels is twofold: firstly, to reduce its reliance on foreign energy (since it has virtually no oil production) and, secondly, to reduce the emission of pollutants to help limit climate change. Therefore, the EU set 2% of all petrol and diesel at 31 December 2005 and 5.75% at 31 December 2010 as targets for biofuels.[2]

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* Corresponding author. Tel.: +34 934020813.
E-mail addresses: jordi.perdiguero@ub.edu (J. Perdiguero), jljimenez@daea.ulpgc.es (J.L. Jiménez).
[1] Tel.: +34 928458191.

[2] Directive 2003/30/EC of the European Parliament and the Council of 8 May 2003. See Hernández and Rodríguez [3] for a critical analysis about this directive and their application to Spain.

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Member states can themselves introduce measures to encourage the consumption of biofuels to reach this objective. These measures have focused on tax exemption for firms that invest in technology to produce biofuels as well as the charging of a lower consumption tax for biofuels. For a detailed description of the measures taken by countries see Bozbas [1] and Wiesenthal et al. [2].

In Spain, a fiscal deduction of 10% for renewable energy investments in corporation tax and the removal of the special tax on fuel until 2013 have been introduced as a national policy measure.[3] Besides, the Ministry of Industry, Tourism and Trade is considering the introduction of new measures to encourage the consumption of biofuels, introducing in the draft Law on Energy Efficiency and Renewable Energy the requirement to have a biofuel pump at all those service stations that sell more than 3 million liters per year.

In this paper, we analyse the role of market structure, local government action and technical problems plays in the penetration of biofuels and how the public policy can encourage the introduction of biodiesel.

Although in recent years the effect of biofuel production on economic development has been deeply analysed (Ryan et al. [4]; Frondel and Peters [5]; Charles et al. [6]; Hahn and Cecot [7]), regarding the effect of fiscal policy on the development of industry (Wassell and Dittmer [8]; Vedenov and Wetzstein [9]), the effect on countries producing raw materials (Pousa et al. [10]; Peters and Thielmann [11]; Lamers et al. [12]; Gucciardi and de Souza [13]; Leite et al. [14]; Bastian-Pinto et al. [15]; Mathews and Goldsztein [16]),[4] and the plans for the use of biofuels in different countries (Kondili and Kaldellis [18]; Huang and Wu [19]; and Boukis et al. [20]) there is no, as far as we know, analysis of what promotes the penetration of biodiesel in the retailing sector, a key element to ensuring the survival of the industry.[5]

In fact, the unique study that has examined empirically the introduction of biofuels is Corts [23], which analyzes the penetration of ethanol in the U.S. market. However, as well as the author explains, the case is significantly different from ethanol and biodiesel because ethanol cannot be consumed by conventional cars aspect that decisively affects the retailing of this type of biofuel. There are some papers that have analyzed the possible penetration of biofuel, taking into account macroeconomic factors: price of oil, technological level in the production of biofuels or alternative land uses. It is particularly interesting Szulczyk et al. [24] for the case of ethanol in the U.S. market and Szulczyk and McCarl [25] for biodiesel in this same country. For the Spanish market highlights Hernández et al. [26] which analyzes the competitiveness and penetration of biofuels in Spain. Unlike the previous articles we do not focus on incentives for the producers of biofuels, but on factors affecting the decision of the pump or not to sell biodiesel.

This article presents a set of contributions on the literature. First, it should be noted that this is the first time that factors affecting the penetration of biodiesel in the market of traditional fuels have been analyzed. Equally a novel set of explanatory factors for the decision to sell biodiesel, or not, are used in the empirical analysis. These explanatory factors include the level of local competition in the market, the differences in cost between service stations, the technical difficulty of selling this type of biofuel and the possible influence of local government in developing the biodiesel market in Spain.

The empirical results show how the level of competition, cost differences and technical difficulties of service stations significantly affect the decision of whether to sell biodiesel or not. Similarly, the results show how the characteristics and the measures introduced by local governments can significantly affect the market development of biodiesel.

After this introduction, the rest of the paper is structured as follows: the main characteristics of the biodiesel market in Spain are explained in Section 2; Section 3 includes the database used in the econometric specification, which is developed in Section 4. The results are shown in Section 5. The article ends by presenting the main conclusions and policy recommendations.

2. The biodiesel market in Spain

In the market for biofuels, biodiesel plays a predominant role in the Spanish market, since the consumption of bioethanol is much smaller than in the U.S. Most European countries, contrary to what happens in America, share this feature.[6] For this reason, we focus on the biodiesel market.[7]

In this market, as pointed out by the report of the Spanish regulator Comisión Nacional de la Energía (CNE) [27], there are numerous barriers that limit development, both with technical and related characteristics. With respect to the technical aspect, we find the crystallization and solidification of fuel microbial growth during pipeline transport, instability in storage and solvent power and the incompatibility with some plastic components in the diesel engines of some vehicles manufacturers. Murugesan et al. [28] presents a detailed analysis on possible technical problems in the implementation of biodiesel. Among others: the high costs of raw materials and production; regulatory uncertainties, mainly in agriculture, which creates uncertainty about the availability of raw materials in the future; the absence of assurances from the producers of vehicles on the proper functioning of the engines; the lack of information for users; and, finally, the poor integration of biofuels into the distribution chain of conventional fuels.

As also indicated by CNE [27], technical barriers should not be insurmountable for market development, as they can be solved relatively easily in the production, transportation and marketing of biodiesel blended with conventional fuel in percentages of up to 30%, as is the case of Spain.

Concerning the second type of barrier, the high costs of raw materials and production as well as the poor integration of biofuels into the distribution chain of conventional fuels are, without doubt, the most important.[8]

Major steps taken by European countries to compensate for the high costs of raw materials and production, as we noted, have been tax exemption, partial or total. For the specific case of Spain, the main legislative reference is the Order of the Ministry of Industry, Tourism and Commerce ITC/2877/2008 promoting the use of biofuels and the like for transport and the Law 34/1998, which established annual targets for biofuel use in the Spanish territory. Among the tax measures introduced in this Order are the establish-

[3] These measures are included in the Order of the Ministry of Industry, Tourism and Trade ITC/2877/2008.

[4] An example on the environmental effect of the adoption of such fuels is Sartzetakis and Tsigaris [17].

[5] Articles like those of Rask [21] and Luchansky and Monks [22] have analysed the behaviour of supply and demand for bioethanol in the U.S., while focusing on the analysis of its elasticity and not on the diffusion or penetration of the product in the fuel retail market.

[6] EU Climate Package includes attempting to renewable sources. For example, 10% of transport fuels will have to come from renewables, including biofuels. The Commission wants to ensure that only biofuels achieving a real cut of at least 35% in CO_2 emissions will be allowed.

[7] It is useful to note that biodiesel is essentially made from vegetable oils such as rape sedd, conola, cotton and palm seed oils, which implies significant competition with health and food markets that also use vegetable oils.

[8] Although there is some uncertainty about the future availability of raw materials, the existence of an international market to some extent helps to overcome that barrier. Similarly, there are already many automobile manufacturers that ensure the smooth operation of their vehicles in the case of using biofuels. Concerning the lack of information, measures to identify suppliers of biofuel and diffusion measures of the environmental benefits of biofuels have been instituted.

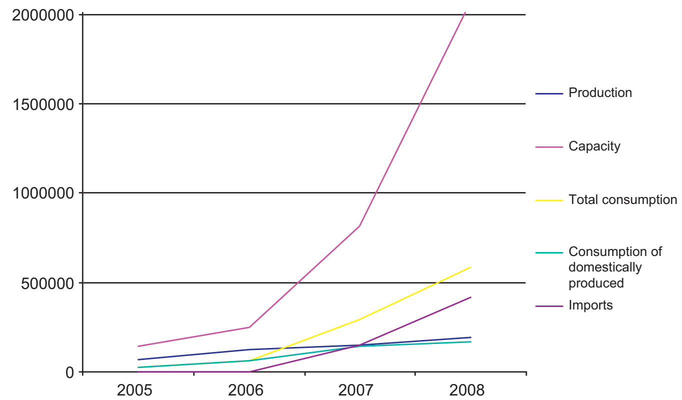


Fig. 1. Capacity, production, consumption and biodiesel imports in Spain. Tonnes per year.
Source: APPA Biocarburantes.

ment of a zero tax rate on biofuels until 31 December 2012.[9] This exemption seeks to compensate for the higher cost of biofuels production with respect to traditional fuels and it takes into account their lower polluting capacity.

Measures to promote research and development techniques that reduce production costs have been established in the production segment.[10] In addition to these tax measures, a regulation that set the minimum amounts of biofuels that operators must compulsorily consume has been passed. These biofuels are consumed by mixing with conventional fossil fuels. Spain currently sells biodiesel blended with traditional fossil fuel (with a maximum of 5% biodiesel), or under the name of biodiesel where the content of biofuels increase to 20%. This latter is the type of marketing that we analyze in this study.

Due to these measures production capacity shows a remarkable increase in recent years.[11] However, they have not yielded a competitive Spanish market for biodiesel, so it has lost market share in recent years, resulting in capacity utilization rates of biodiesel production plants that are economically unsustainable.

From Fig. 1 and the table in Annex A, we can discern that only 4 out of 36 plants in 2008 (11%) are at a capacity utilization above 50%. Another 9 plants (25%) produced with a level of capacity between 10 and 50%, while the remaining 64% (23 plants) used between 0 and 10% of their available capacity.

One of the main reasons that consumption does not follow the path of production capacity is its limited inclusion in the distribution chain of conventional fuels. Thus, the percentage of service stations that dispense biodiesel is very small: only 8.6% of gas stations in our sample. This can also be inferred from the trend in the consumption of biodiesel in the past 2 years.

As shown in Fig. 2, the total consumption of this biofuel has fallen since mid 2008 at a monthly negative average rate change of 4.7%, especially in regard to direct sales, although its use for increasing the octane of conventional diesel (the "mixture" curve in Fig. 2) has also suffered a substantial reduction.

Summarizing, the biodiesel market outlook for Spain is not encouraging. The production segment is oversized, with a production capacity of 2,070,020 tons per year in 2008, 12 times the consumption that occurred in that year. Also, the segment is clearly not competitive with foreign producers, as evidenced by the increase in imports in recent years. These facts result in the economic infeasibility of a large number of existing plants, unless consumption increases further in the coming years, both in Spain and Europe.

In the retail marketing segment, the integration of biodiesel into channels of conventional fuels is almost zero, limiting the consumption of this fuel and decreasing the viability of the productive segment.

3. Data

In order to estimate which elements can affect the adoption of a new product such as biodiesel, we have information on all the service stations operating in the four major Spanish cities: Madrid, Barcelona, Seville and Bilbao.[12]

For each stations we have information on whether biodiesel is sold or not, and also the area of each gas station in metres squared. Information on whether the gas station sells biodiesel was obtained from the Ministry of Industry, Tourism and Trade's website. Meanwhile, the surface of each of the stations has been estimated through information obtained from Google Earth. Using this computer programme we calculate the dimensions of each of the stations and subsequently the surface area.

For each of the stations we also obtained the number of competitors within a half a mile radius. This calculation required the georeferencing of each of the 243 petrol stations, fixing the longitude and latitude and calculating the Euclidean distance to other stations of different brands, as a proxy for competition in the market.[13] This calculation was performed using the Matlab software.[14] Once we had calculated this distance, we obtained the number of service stations within half a mile.[15]

Following this approximation we have also calculated the biodiesel production capacity that exists 30 miles away from each station. To obtain this information we have georeferenced the position of each of the biodiesel production plants in Spain and subsequently calculated which one is at a distance of less than 30 miles, before adding the production capacity of these plants. The address of each production plant is obtained from the company APPA biofuels.

For demand variables we obtained the population and population density of each of the four cities. This information was obtained from the National Statistics Institute (INE). We have also created a dummy variable that takes a value of one if the station is in one of the main entry/exit roads of the city and zero otherwise.

Regarding the variables related to local government we have constructed a dummy variable that takes a value of one if the government is from the right-wing and zero if the government is from the left-wing. This information was obtained from the website of the Ministry of Interior. We also have information on the percentage of public transport buses that consume biodiesel in respect to the total bus fleet. Finally we have constructed a dummy variable that takes a value of one if the provision of urban transport by bus

[9] Article 6.5 of Law 53/2002 of 30 December.

[10] The latter stresses Law 55/1999 of 29 December on fiscal administrative and social order, where amending Articles 33 and 35.4 of Law 43/1995 on corporate income tax look at the tax deductions for activities of research, development and technological innovation and investment in environmental protection. Other investment credits are include in: Law 24/2001 of 27 December on fiscal, administrative and social order amending Article 122 of Law 43/1995.

[11] Annex I includes the list of biodiesel production plants operating in Spain during 2008 and those planned for launch during 2009.

[12] We have information on the ten biggest cities in Spain in terms of population but only in the four mentioned is there any point of sale that provides biodiesel at mid-2009.

[13] In the Spanish gasoline market, there is no competition between the stations of the same brand as the company's wholesale division fixes the final retail price directly or indirectly. Thus, only the number of stations that are of different brands was calculated.

[14] The Matlab code for the calculation of these distances is available upon request from the authors'.

[15] 1/2 mile = 804.672 m.

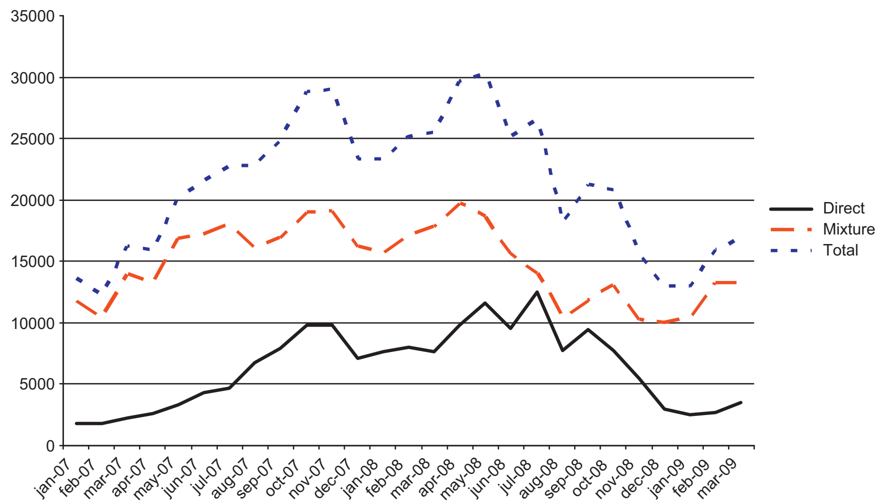


Fig. 2. Monthly evolution of the consumption of biodiesel. Spain. 2007–2009.
Source: Corporación de Reservas Estratégicas de Productos Petrolíferos (CORES).

Table 1
Descriptive statistics.

	Obs.	Mean	Std Dev.	Min.	Max.
No. Comp_i	245	0.849	1.078	0	5
No. Comp_i^2	245	1.878	3.592	0	25
Cap. Ref. 30 miles	245	73097.96	65254.47	31,000	400,000
Population	245	2,307,671	1,086,953	354,860	3,255,944
Dens. Pop.	245	8045.711	4622.176	4994.36	15991.49
Main way	245	0.310	0.464	0	1
Surface	243	379.125	359.922	9	2613
Gov. right	245	0.571	0.496	0	1
% Bio. bus	245	0.283	0.153	0	0.421
Privatization	245	0.029	0.167	0	1

By city	Total petrol stations	Percentage	Petrol stations that offer biodiesel
Madrid	133	54.29%	4
Barcelona	61	24.90%	14
Sevilla	44	17.96%	2
Bilbao	7	2.86%	1

Source: Authors' calculations.

is performed by a private company and zero if it is provided publicly. This information has been obtained from the websites of the various urban transport bus companies.

Table 1 shows the descriptive statistics of the variables mentioned above.

Of the total of 245 service stations in the 4 cities considered, an average of 1 competitor in half a mile (0.849) is not achieved. The minimum number of competitors in that distance is 0 and the maximum is 5. Regarding the distribution by city, Madrid has more than half the stations, followed by Barcelona, Seville and Bilbao.

4. Hypothesis and empirical approximation

To approximate the elements that influence the decision to sell or not biodiesel by gas stations empirically we estimate the following expression:

$$\begin{aligned} Y_i = {} & \beta_0 + \beta_1 \text{No. Comp}_i + \beta_2 \text{No. Comp}_i^2 + \beta_3 \text{Cap. 30 miles}_i \\ & + \beta_4 \text{Pop.}_j + \beta_5 \text{Pop. Dens.}_j + \beta_6 \text{Main way}_i + \beta_7 \text{Sur.}_i \\ & + \beta_8 \text{Right}_j + \beta_9 \text{Bio. bus}_j + \beta_{10} \text{Priv.}_j + \varepsilon_i \qquad (1) \end{aligned}$$

where Y_i is a dummy variable that takes the value 1 if the service station "i" sells biodiesel and 0 otherwise. We test whether this decision depends on the number of rivals who have a service station within half a mile (No. Comp_i) and its square (No. Comp_i^2), on the production capacity of biodiesel in 30 miles, on the population and density of population, whether the gas station is located on a main road of the city, the area occupied by the gas station and a set of variables of the local government, including whether local government is from the right or from the left, whether to privatise the bus transport, and the percentage of biodiesel buses on the total fleet. Next we discuss the different hypotheses we have for different groups of variables.

4.1. *Level of local competition*

One of the first aspects that can affect the decision to sell biodiesel is the level of competition in the market. In the Industrial Organization literature there is huge empirical evidence on the relationship between market structure and the introduction of a new product, if we understand the latter as an innovation.[16] The first empirical evidence followed the idea proposed by Schumpeter [30], which specified a negative relationship between the level of competition and innovation processes. Other authors have found, however, positive relationships between competition and innovation, such as Nickell [31] or Blundell et al. [32].

In both cases, the authors use linear approximations, although Scherer [33] had already demonstrated that the relationship between these two variables is not linear but presents an inverted U shape: it grows in the presence of relatively few competitors to reach a peak from which, by introducing more firms, the level of innovation is reduced. Aghion et al. [34] tested this empirical evidence for a large panel of firms in the UK. Surprisingly, there are not a large number of empirical articles analysing the existence of this nonlinear relationship between competition and innovation and even fewer in an energy industry. For the construction of the variable that approximate the level of competition in the market, we followed the strategy for the sector described by Shepard [35] and

[16] Schumpeter [29] defines innovation as: "The introduction of a new good – that is one with which consumers are not yet familiar – or of a new quality of a good". Therefore, the introduction of biodiesel in each of the pumps could be understood as a process of innovation.

Perdiguero and Borrell [36], estimating the number of competitors that exist within a distance of half a mile.[17]

To satisfy the inverted U relationship described in the literature, we should observe a positive sign in the coefficient of the number of rivals in half a mile ($\beta_1 > 0$) and a negative coefficient for its square ($\beta_2 < 0$). These are the two hypotheses that we test empirically.

4.2. Biodiesel production capacity

As indicated by Corts [23] biofuels cannot be transported with other fuel through pipeline networks. Biofuels must be transported by tanker from the production site to the service station, which can be significantly more expensive for those outlets further away from the production centres. To capture this potential effect as an explanatory variable includes the refining capacity installed in an existing 30-mile radius from each station. The lower the installed production capacity around the gas station the higher the cost of obtaining supplies of biodiesel, since it will have to be acquired from more distant production sites. This makes more production capacity installed around the gas stations and more probability of selling biodiesel: ($\beta_3 > 0$).

4.3. Demand factors

We also included variables that can affect fuel consumption in general, such as people living in the city and its density as well as a variable that reflects whether the gas station is located on one of the main routes of entry or exit of the city, an element which may affect the demand for fuel. Gas stations that support a higher demand may gain greater benefit and be able to invest in the necessary resources to sell biodiesel more easily. However, a pump with higher demand for fuel does not necessarily have a greater demand for biodiesel. On the contrary, if demand is intensive fuel consumption can be very sensitive to price over the number of kilometers traveled per liter of fuel. There is evidence in the literature (Corts [23]) that shows how biofuels have lower energy capacity than fossil fuels. Therefore, the sign of the demand variables will be determined in the econometric estimation.

4.4. Technical problems

Another element that can have a significant impact on the decision of whether to sell biodiesel is the ease in which a service station can adapt a space for the sale of this type of biofuel. Biodiesel requires a special storage tank, an outlet made of materials capable of withstanding the most corrosive power of this type of fuel. Therefore, we expect that the larger petrol stations are more likely to adapt to selling biodiesel. In our empirical approach we include the square meters of the service station as a proxy for the technical facility to bring the gas station to sell biodiesel, so we expect: $\beta_7 > 0$.

4.5. Local government characteristics

Finally we included a set of variables that describe the characteristics of local governments as well as measures in the field of urban transport. A first element that we have considered is whether the government is from the right or from the left. Traditionally governments from the Left are considered to be more concerned with environmental problems and therefore more prone to develop a market for biodiesel.

One area in which local government can help to develop a market for biodiesel is the management of urban transport. In their study Corts [23] shows how the purchase of vehicles that consume ethanol by the government encouraged the number of gas stations that sell these products. In our case, one way to help develop the market for biodiesel may be the purchase of buses that use this type of biofuel. We have therefore introduced a variable that measures the percentage of the total bus fleet that uses biodiesel. We expect that this variable will generate a positive effect on the probability of selling biodiesel: ($\beta_9 > 0$). An element closely related to urban transport is whether the management is public or private. If we think a private company holds the concession for the service for a number of years, it will probably have less incentive to make costly investments in new buses that use biodiesel, more so considering that the useful life of these buses can exceed the concession period. Therefore, urban transport services that are privatized can have a negative impact on the consumption of biodiesel and therefore on the probability of a service station selling this type of fuel: ($\beta_{10} < 0$).

Before proceeding to show the empirical results there are a number of aspects that we have to take into account. First, in addition to the institutional differences that may exist between regions and that would be reflected in the dummy variables for the cities, there might be heterogeneity among the service stations in the regions. To solve this problem of heteroskedasticity and to obtain a robust variance–covariance matrix, we introduce a cluster in a city that takes into account this feature of the data.

Secondly, there may be spatial autocorrelation in the residuals of our estimates. To check whether or not the errors are spatially correlated, we calculated Moran's test using the Stata command "spatcorr" as performed by Corts [23]. As in the case of Corts [23], Moran's statistic does not, in any case, reject the null hypothesis that errors are not spatially correlated.

Finally, we note that the sample is a small number of positive cases. In fact, 8.6% of the total number of service stations in these 4 cities offer biodiesel (21 outlets). This low level of values can lead to the logit estimator reaching results that might not be efficient. To solve this problem, we estimate the model described by a "complementary log–log model". This type of logistic model takes into account that the database can be unbalanced, because there is either a low probability of occurrence or a high probability. The results obtained are shown in the following section.

5. Results

Table 2 contains the estimation using the "complementary log–log model",[18] in seven different specifications depending on the number of variables included. These different specifications will help us verify the robustness of our analysis and show that there are problems of omission of relevant variables that might bias our results.

The estimates show that the coefficient of the number of rivals who are half a mile away is positive and significant in all cases as well as its square being negative and significant. This empirical evidence indicates that there seems to be an inverted U-shaped relationship between competition and opportunities to innovate in the market, as indicated by Aghion et al. [34].

To show more clearly the inverted U relationship between the incorporation of biodiesel and the number of competitors in half a mile, we perform a series of simulations to deter-

[17] For a similar approximation see Chakravorty et al. [37] which analyse the effects of US Clean Air Act on wholesale gasoline prices. To do that, they introduce the regulatory distance measure as a proxy for measuring market power to influence on prices. These authors conclude that higher distance, higher probability to increase prices.

[18] We do the same estimations using a logit estimator. Results do not change significantly and they are available upon request authors.

Table 2
Complementary log–log models, robust.

	Est. 1	Est. 2	Est. 3	Est. 4	Est. 5	Est. 6	Est. 7
Constant	−4.703[c] (0.188)	−4.666[c] (0.154)	−4.790[c] (0.183)	−10.932[c] (0.352)	−4.703[c] (0.188)	−5.609[c] (0.241)	−5.643[c] (0.256)
No. $Comp_i$	0.456[b] (0.237)	0.465[b] (0.231)	0.456[b] (0.238)	0.456[b] (0.238)	0.456[b] (0.238)	0.456[b] (0.238)	0.465[b] (0.234)
No. $Comp_i^2$	−0.106[a] (0.061)	−0.110[a] (0.064)	−0.106[a] (0.061)	−0.106[a] (0.061)	−0.106[a] (0.061)	−0.106[a] (0.061)	−0.110[a] (0.064)
Cap. 30 miles	9.89e−06[c] (5.23e−07)	0.00001[c] (1.19e−06)	9.89e−06[c] (5.23e−07)	9.89e−06[c] (5.23e−07)	9.89e−06[c] (5.23e−07)	9.89e−06[c] (5.23e−07)	0.00001[c] (1.19e−06)
Surface	0.0003[c] (0.0001)	0.0003[c] (0.0001)	0.0003[c] (0.0001)	0.0003[c] (0.0001)	0.0003[c] (0.0001)	0.0003[c] (0.0001)	0.0003[c] (0.0001)
Population	−3.03e−07[c] (2.11e−06)	−3.18e−07[c] (2.37e−08)		−5.04e−06[c] (1.05e−07)	−3.03e−07[c] (2.11e−08)		
Dens. Pop.	0.0002[c] (1.55e−06)	0.0002[c] (3.73e−06)	0.0002[c] (1.37e−06)	0.0008[c] (0.00002)	0.0002[c] (1.55e−06)	0.0002[c] (2.52e−06)	0.0002[c] (4.89e−06)
Main way		−0.169 (0.218)					−0.169 (0.218)
Right			−2.705[c] (0.091)			−2.053[c] (0.043)	−2.197[c] (0.208)
Bio. bus				0.441[c] (0.012)		0.048[c] (0.004)	0.051[c] (0.007)
Priv.					−2.905[c] (0.077)		
Observations	243	243	243	243	243	243	243

Note: Fixed effects of cities are not included in the table.
[a] 10%.
[b] 5%.
[c] 1%.

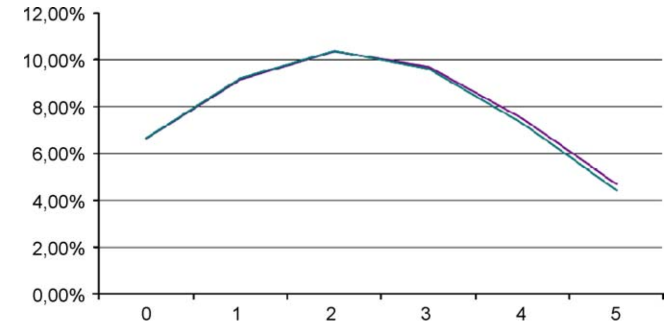


Fig. 3. Evolution of the probability of selling biodiesel depending on the number of competitors in half a mile.
Source: Authors' calculations.

mine the likelihood of its existence, as summarized in the figure below.

As seen in Fig. 3, in all the specifications, the maximum probability is reached in a market structure with 2 opponents in less than half mile. Considering that the average rivals in our sample do not reach 0.9, we conclude that there is indeed potential for increasing the marketing of biodiesel incident to market structure, i.e. increasing the level of competition that exists today. We should note that Spain has one of the lowest densities of petrol per thousand inhabitants in all of Europe, which we estimate would explain, at least in part, the low level of commercialization of biodiesel.

The installed production capacity of 30 miles is positive and significant in all cases as we expected. Gas stations that have a greater production capacity of biodiesel installed nearby reduce their transport costs and increase the probability of introducing this type of biofuel. Hernández et al. [38] indicated that biorefineries should be close to agricultural producers to minimize transportation costs. The results in this paper show that the costs of transporting the biodiesel has an important role. In fact having biorefineries around the outlets increases the possibility that gas stations sell biodiesel. It seems that the transport of the raw material is cheaper than transporting biodiesel. It should be noted that in Spain there are no pipes to transport biodiesel, so it must be done by the most expensive method of transport, by truck.

Regarding the surface of the station is also positive and significant at 1% in all cases. This result confirms our hypothesis that larger stations have fewer technical problems to bring a tank and a pump to sell biofuels.

Regarding the demand variables, the population is negative and significant, while the population density is positive and significant. Finally, the variable measuring whether the service station was located in one of the main entry/exit roads of the city is not statistically significant.

Finally, the variables that describe the characteristics of different local governments are all significant at one per cent. The right variable indicates that right-wing governments are probably less sensitive to environmental problems and have a significant negative effect on the probability of selling biodiesel. In this sense the variable privatization shows how the privatization of urban transport management has a significant and negative effect on the probability of selling biodiesel. Finally we can observe how the percentage of buses that consume biodiesel shows a significant positive relationship with the probability of selling biodiesel. As in the case of ethanol in the United States as shown by Corts [23], it seems that the creation of demand through an increased fleet of buses that consume biodiesel helps increase the likelihood that service stations offer this biofuel.

6. Concluding remarks

The introduction of renewable energy to help reduce CO_2 emissions and therefore to comply with environmental commitments is a primary objective in Europe. Both in Europe and in Spain several incentives have been introduced for the development of the biofuel industry and more specifically biodiesel. As a result of these measures, there has been a steady increase in production capacity in Spain, which contrasts with the moderate growth in demand and the strong increase in the percentage of imports. This fact causes many plants to operate below 10% of their capacity, a threshold that makes the continuing development of the market unviable.

To explain the low penetration of biodiesel in the Spanish retailing market, we have discussed how service stations make the decision to offer this new product. Among the factors that may affect this decision we take into account the level of local competition, cost elements such as proximity to the production plants or the facility to adapt the service stations, demand elements, and finally characteristics of local governments.

The empirical results show that the relationship between the level of competition and the probability of introducing the new product is nonlinear, and specifically an inverted U relationship. The presence of one or two competitors within half a mile increases the probability of introducing the new fuel while having greater competitive pressure reduces the chance of having it. This relationship between innovation (considering introducing a new product as an innovation) and market structure is widely established in the literature of Industrial Organization.

Considering that Spain has one of the lower densities of petrol stations in Europe, and that the transition from public monopoly to the deregulated market cannot yet generate effective competition in the market, Spain can provide consumption levels of biofuels that are too low, at least in part, in relation to its market structure.

Another element that may play an important role in the development of biodiesel in Spain is the urban transport fleet. The existence of public enterprises to manage urban transport and increase the number of buses that consume biodiesel has a significant impact on the market development of biodiesel.

Given the empirical results obtained in this study, a way to promote the consumption of such fuel would be to introduce more competition into the market, either through new entrants or by facilitating a change of brand of the retailers established in the market, which would mean that there are traders of different brands in each market. Encourage the location of biorefineries near points of consumption also increases the probability that service stations sell biodiesel. Also an active policy by local governments in the acquisition of buses that use biodiesel can help increase the number of gas stations that sell biodiesel.

Annex A. Production and projections of biodiesel production in Spain

See Tables A1–A3.

Table A1
Biodiesel plants in Spain on 31 December 2008.

Firm	Locality	Province	Capacity (tonnes)
Infinita Renovables	Castellón	Castellón	300,000
Bioenergética Extremeña 2020	Valdetorres	Badajoz	250,000
Bio-Oils Huelva I	Palos de la Frontera	Huelva	250,000
Combustibles Ecológicos Biotel	Barajas de Melo	Cuenca	150,000
Biocarburantes CLM	Ocaña	Toledo	105,000
Biodiesel Aragón	Altorricón	Huesca	100,000
Linares Biodiesel Technology	Linares	Jaén	100,000
Biocom Energía	Algemesí	Valencia	75,000
Biodiesel Caparroso	Caparroso	Navarra	70,000
Biocombustible de Cuenca	Cuenca	Cuenca	50,000
Ecoproductos Cast. La Mancha	Montalbo	Cuenca	50,000
Bionet Europa	Reus	Tarragona	50,000
Entabán Biocomb. Guadalquiv.	Sevilla	Sevilla	50,000
Biodiesel Castilla la Mancha	Santa Olalla	Toledo	45,000
Biodiesel de Andalucía 2004	Fuentes de Andalucía	Sevilla	40700
Combunet	Monzón	Huesca	40,000
Energía Gallega Alternativa	Cerceda	A Coruña	40,000
Bionor Berantevilla	Berantevilla	Álava	35,320
Biocarburantes de Galicia	Begonte	Lugo	35,000
Grupo Ecológico Natural	Llucmajor	Baleares	33,000
Stocks del Vallés	Montmeló	Barcelona	31,000
Hispanergy Puertollano	Puertollano	Ciudad Real	25,000
Entabán Biocomb. Del Pirineo	Alcalá de Gurrea	Huesca	25,000
Biocarburante Almadén	Almadén	Ciudad Real	21,000
Biocarburante de Castilla	Valdescorriel	Zamora	20,000
Diesol	Alcalá de Henares	Madrid	15,000
Bioteruel	Albalate del Arzobispo	Teruel	10,000
Comb. Ecol. Mediterráneo	Elda	Alicante	10,000
Albabío Andalucía	Níjar	Almería	6000
Biocarburos de Almanzora	Cuevas de Almanzora	Almería	6000
Biodiesel Carburantes	Carranque	Toledo	6000
Bercam	Los Yébenes	Toledo	6000
Bionorte	San Martín del Rei	Asturias	5000
Biocomb. De Castilla y León	San Cristóbal de Entrevías	Zamora	6000
Transportes Ceferino Martínez	Vilafant	Girona	5000
Asthor Biodiesel	Gijón	Asturias	4000
Total			2,070,020

Source: APPA Biocarburantes.

Table A2
New biodiesel production capacity in Spain. Year 2009.

Firm	Locality	Province	Capacity increase (tonnes)
Infinita Renovables	Castellón	Castellón	300,000
Infinita Renovables	Ferrol	A Coruña	300,000
Iniciativas Bioenergéticas	Calahorra	La Rioja	250,000
Abengoa San Roque	San Roque	Cádiz	200,000
Biodiesel Bilbao	Ziérbana	Vizcaya	200,000
Saras Energía	Cartagena	Murcia	200,000
Cogeneración de Andújar	Andújar	Jaén	200,000
Biocombustibles de Ziérbana	Ziérbana	Vizcaya	200,000
Entabán Biocomb. de Galicia	Ferrol	A Coruña	200,000
Biocarburantes Peninsulares	Narón	A Coruña	120,000
Greenfuel Extremadura	Los Santos de Maimona	Badajoz	110,000
Sdad. Coop. Gral. Agrop. Acor.	Olmedo	Valladolid	100,000
Aceites del Sur–Coosur	Tarancón	Cuenca	50,000
Dipesa Gestión	Madrid	Madrid	50,000
Augas Mansas	As Pontes	A Coruña	34,000
Solartia	Los Arcos	Navarra	28,500
Hispanergy del Cerrato	Herrera de Valdecañas	Palencia	25,000
Biocom Pisuerga	Castrojeriz	Burgos	6000
Total			2,273,500

Source: APPA Biocarburantes.

Table A3
New biodiesel production capacity in Spain projected to 2010.

Firm	Locality	Province	Capacity increase (tonnes)
Bio-Oils Huelva II	Palos	Huelva	250,000
Greenfuel Aragón	Andorra	Teruel	110,000
Biodiesel de la Ribera	Milagro	Navarra	16,100
Total			376,100

Source: APPA Biocarburantes.

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